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MRS 1999 Fall Meeting

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Symposium Title: Multiscale Phenomena in Materials: Experiments and Modeling

IN-SITU TRANSMISSION ELECTRON MICROSCOPY STUDIES OF DISLOCATIONS IN THIN FILM SYSTEMS E.A. Stach, National Center for Electron Microscopy, Lawrence Berkeley National Laboratory, Berkeley, CA; R. Hull, Department of Materials Science, University of Virginia, Charlottesville, VA; R.M. Tromp, F.M. Ross, K.W. Schwarz and M.C. Reuter, Research Division, IBM T.J. Watson Research Center, Yorktown Heights, NY; W.D. Nix and J. Florando, Department of Materials Science, Stanford University, Palo Alto, CA.

In-situ transmission electron microscopy of thin films systems provides an ideal experimental laboratory for the study of dislocation motion and dislocation – defect interactions in materials. Through careful consideration of the sample geometry and calibration of the experimental conditions it is possible to obtain accurate quantitative information about dislocation velocities, interaction stresses and overall strain relaxation behavior. A model materials system for studies of dislocation behavior is heteroepitaxial SiGe layers grown on Si substrates. In this case the difference in lattice parameter between the layers results in mismatch strains and stresses whose magnitude can be directly controlled by the choice of germanium concentration and sample thickness. During growth and annealing within the microscope, dislocations nucleate and grow in order to relieve this mismatch strain. Quantitative observations of the interaction between moving threading dislocations and other interfacial misfit dislocations will be presented. These observations are amenable to direct comparison with mesoscale modeling of dislocation dynamics, and we will discuss in particular the interplay between experimental observation and computational modeling that has lead to understanding of the important phenomenon of 'reactive blocking' in heteroepitaxial strain relaxation. Additionally, it is possible to use thermal mismatch strains to move dislocations through thin films. Results from *in-situ* thermal cycling of sputter-deposited aluminum films grown on silicon-on-insulator wafers will also be discussed. Use of selective etching techniques permits observation of free standing Al / Si layers *in-situ*, allowing one to identify the dislocation mechanisms that control strain relaxation in these films. These observations can be correlated with direct measurements of strain relaxation made by wafer curvature and bulge testing techniques, providing an important cross-link with other experimental methods of studying dislocation-based strain relaxation.

Presenting Author:
Last Name: Stach
First name: Eric M.I.: A.
Institution: Lawrence Berkeley National Laboratory
Department: National Center for Electron Microscopy
City: Berkeley
State: California Zip Code: 94720
Country: United States
Phone: 510.486.4634
Fax: 510.486.5888
email: EAStach@LBL.gov